Appendix F

Methods for Evaluating Impacts on Health from Radionuclides and Chemicals

This appendix describes details of the methodology used to evaluate health impacts for the alternatives considered in the Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement (HSW EIS). Unless otherwise specified, the data used for the analysis are provided in the Technical Information Document prepared by Fluor Hanford (FH 2003), the Solid Waste Information Tracking System (SWITS) database (Anderson and Hagel 1996; Hagel 1999; FH 2003), or the Solid Waste Integrated Forecast Technical (SWIFT) Report (Barcot 1999, 2002).

F.1   Normal Operation Impact Assessment Methods

Under normal waste management operations, atmospheric releases of radionuclides and chemicals could occur. This section describes methods used to estimate annual quantities released, atmospheric transport, exposure scenarios, and health impacts assessment of these releases.

The methods used are based on source and waste stream information presented in Section 3 and on the affected environment from Section 4. The atmospheric transport and health impacts were evaluated using the Multimedia Environmental Pollutant Assessment System (MEPAS) Version 4.0 (Droppo and Buck 1996; Strenge and Chamberlain 1995). This version is an enhancement of earlier versions (for instance, Version 3.1 [Buck et al. 1995] and Version 3.2 [Buck et al. 1997]) and is designed to operate under the Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES) described by Whelan et al. (1997). The MEPAS program was selected because it is capable of evaluating health impacts from radionuclides and chemicals, and it can model time-varying releases, deposition, and accumulation in soil. Doses to hypothetical maximally exposed individuals (MEIs) are intended to bound potential impacts but not to reflect an expected set of typical circumstances.

The atmospheric dispersion models in the MEPAS program provide nearly identical results to those generated using the U.S. Environmental Protection Agency (EPA) CAP88 program, as verified in a benchmarking study performed on the MEPAS, MMSOILS, and RESRAD computer programs (Mills et al. 1997). The RESRAD program uses the CAP88 program for atmospheric transport calculations (Cheng et al. 1995).

F.1.1   Pollutant Releases to the Atmosphere

Pollutant releases to the atmosphere may occur from any of the facilities handling or containing any of the several waste streams identified for this HSW EIS, as described in Section 2. The release rate must

1   be evaluated as a function of time during the period of operation because the volumes of waste processed
2   vary by year. For a given facility and year, the annual release is determined by the quantity of waste
3   processed or stored in the facility during the year, the average concentration of each pollutant in the waste
4   while in the facility, and the fraction of the pollutant that is released to the atmosphere. The annual
5   release from a given facility can be expressed in Equation F.1.
6
7    $$R_i = \sum_{i=1}^{n} V\, C_i\, F_i \qquad\qquad\qquad (F.1)$$
8
9   where R_i = release rate of pollutant i from a facility during a given year (Ci/yr or kg/yr)
10   V = volume of waste stream processed in a facility (m^3/yr)
11   C_i = average concentration of pollutant i in a waste stream (Ci/m^3 or kg/m^3)
12   F_i = release fraction for pollutant i from a waste stream processed in a given facility
13   (dimensionless)
14   n = number of waste streams processed in the facility.
15
16   The waste stream volumes are described in Section 2 and in Appendixes B and C. Table F.1 is a
17   cross-reference for Tables F.2 through F.18, which provide concentration data for each waste stream for
18   each alternative. The presumed average concentration of constituents in each waste stream is provided in
19   Tables F.2 through F.18. Waste stream designations are given in Appendix B. The radionuclides
20   included in each waste stream are those that contribute greater than 0.1 percent to inhalation or ingestion
21   dose based on the concentration in the given waste stream. Short-lived radionuclides that are generated
22   from a longer-lived radionuclide (for example, yttrium-90 from strontium-90) in the inventory are not
23   included in the lists because their contributions are included with the parent radionuclide in the dose
24   analysis.
25
26   The analysis of health impacts is performed for each facility using the facility release characteristics
27   (for example, stack height and exit velocity) and annual release rates as input to the atmospheric transport
28   analysis. The transport and exposure pathway analyses evaluate downwind transport, deposition, soil
29   resuspension, soil accumulation, and transfer through exposure pathways to the exposed individuals.
30
31   The release fractions have been defined for each facility and pollutant using information and methods
32   from past analyses. Facilities not included in the list are not expected to release contaminants under
33   normal operating conditions.
34
35   Release fractions were estimated for each facility managing wastes that are evaluated within the
36   scope of this HSW EIS. These facilities and the waste streams associated with each facility are described
37   in Section 2 and Appendixes B and C. Generally, the release fraction estimation is based on previous
38   studies involving the existing facilities or on values for similar facilities. Guidance from 40 CFR 61,
39   Appendix D (consistent with WAC 246-247), also is used for release fraction estimates for the Waste

1   **Table F.1**. Summary of Waste Stream Concentration Tables

2

Stream No.[a]	Waste Stream Description[b]	Table Number
1	LLW Cat 1	F.2
2	LLW Cat 3	F.3
1 and 2	LLW from Offsite	F.4
2c2	LLW Cat 3 for T Plant Processing from Offsite	F.5
4	TRU-RH Waste in Trenches	F.6
4	TRU-CH Waste in Trenches	F.7
5	TRU-CH Waste in Caissons	F.8
8	TRU Waste Containing PCBs	F.9
9	TRU-RH and -CH Drums and SWBs	F.10
10	TRU-CH Boxes	F.10
10	RH-TRU Waste Boxes	F.11
11	MLLW-Treated Ready for Disposal	F.12
12	MLLW-RH and Large Boxes	F.13
13	MLLW-CH	F.14
14	Elemental Lead	F.15
15	Elemental Mercury	F.16
17	K Basin Sludge	F.17
18	Leachate from MLLW Trenches	F.18

(a) Waste stream designations are as described in Appendix B.
(b) Cat = Category; CH = contact-handled; LLW = low-level waste;
     MLLW = mixed low-level waste; PCBs = polychlorinated biphenyls;
     RH = remote-handled; SWB = standard waste box; TRU = transuranic.

3
4   Receiving and Processing Facility (WRAP), the T Plant Complex, the new waste processing facility,
5   and leachate treatment by pulse driers. That guidance includes the following conventions:

6

7   1. Radioactive materials in sealed packages that remain unopened and have not leaked during the
8   assessment period were not included in the calculation.

9

10   2. The release fraction for gaseous material is 1.

11

12   3. The release fraction for liquids and particulate solids is 0.001.

13

14   4. The release fraction for solids is 1E-06.

15

16   5. Credit can be taken for particulate filtration installed between the place of use and the point of release
17   (except for gaseous radionuclides).

1   **Table F.2**. Stream 1 – Low-Level Waste Category 1
2

Constituent	Concentration, Ci/m^3
Americium-241	6.41E-06
Cobalt-60	1.07E-03
Cesium-137	1.01E-04
Iron-55	2.46E-03
Manganese-54	3.29E-03
Nickel-63	8.62E-04
Plutonium-238	2.16E-06
Plutonium-239	3.11E-05
Plutonium-240	7.87E-06
Plutonium-241	2.11E-04
Strontium-90	1.20E-04
Tritium	4.49E+00

3
4   **Table F.3**. Stream 2 – Low-Level Waste Category 3
5

Constituent	Concentration, Ci/m^3
Americium-241	7.94E-03
Curium-244	1.00E-03
Cesium-137	9.77E+00
Plutonium-238	1.97E-03
Plutonium-239	9.44E-03
Plutonium-240	3.73E-03
Plutonium-241	2.23E-01
Strontium-90	1.24E+01
Tritium	1.62E-03
Uranium-234	1.89E-02
Uranium-235	5.40E-04
Uranium-236	2.44E-03
Uranium-238	3.04E-02

6

Table F.4. Streams 1 and 2 – Low-Level Waste from Offsite Sources

Radionuclide	Source Site [a] and Waste Stream Concentrations, Ci/m³											
	BNL	GE VAL	GJPO	INEEL	ITRI	LLNL	ORR	PNTX	RFETS	SNL	SPRU	WV
Tritium	9.66E-05			6.66E+01	1.73E-02	6.97E-03	8.60E+0	5.81E-04	2.47E-05	1.14E+0	1.45E-04	4.80E-01
Carbon-14				2.31E-03	2.92E-03	1.73E-06	4.30E-05			4.07E-04	1.32E-11	4.07E-04
Cobalt-60	1.41E-06	6.18E-04		8.17E+01			3.21E-02			9.50E-01	7.04E-05	9.50E-01
Nickel-59				4.39E-01			1.41E-07			4.70E-03	8.72E-08	4.70E-03
Nickel-63				1.56E+01			5.76E-01			2.12E-01	3.81E-06	2.12E-01
Strontium-90	3.39E-04	3.14E-03		1.14E-02			2.29E-03		4.74E-11	2.53E-01	4.23E-04	2.53E-01
Technetium-99				1.40E-05			2.56E-07			4.19E-05	9.57E-10	4.19E-05
Cesium-137	5.52E-04	2.18E-03	5.52E-14	2.20E-01			2.17E-01		1.70E-08	1.68E-01	6.80E-04	1.68E-01
Uranium-234	7.52E-08			3.08E-06			1.59E-04	7.36E-06	3.15E-07	1.41E-04	3.61E-06	1.41E-04
Uranium-235	2.66E-08			4.36E-05			7.21E-04	1.26E-06	9.47E-11	7.14E-06	1.67E-07	7.14E-06
Uranium-238	5.76E-08			1.88E-03	5.84E-04	4.96E-04	7.85E-05	7.89E-05	2.68E-07	3.27E-04	1.17E-05	3.27E-04

(a) BNL = Brookhaven National Laboratory
　　　GE Val = General Electric – Vallecitos
　　　GJPO = Grand Junction Project Office
　　　INEEL = Idaho National Engineering and Environmental Laboratory
　　　ITRI = Inhalation Toxicology Research Institute
　　　LLNL = Lawrence Livermore National Laboratory

ORR = Oak Ridge Reservation
PNTX = Pantex Facility
RFETS = Rocky Flats Environmental Technology Site
SNL = Sandia National Laboratories
SPRU = Separations Process Research Unit
WV = West Valley Nuclear Services

Table F.5. Stream 2c2 – Low-Level Waste Category 3 Offsite Sources for T Plant Processing

Radionuclide	Source Site[a] and Waste Stream Concentrations, Ci/m^3											
	BNL	GE VAL	GJPO	INEEL	ITRI	LLNL	ORR	PNTX	RFETS	SNL	SPRU	WV
Tritium	3.06E-05			2.11E+01	5.48E-03	2.20E-03	2.73E+0	1.84E-04	7.82E-06	3.60E-01	4.57E-05	1.52E-01
Carbon-14				7.32E-04	9.24E-04	5.46E-07	1.36E-05			1.29E-04	4.19E-12	1.29E-04
Cobalt-60	4.47E-07	1.95E-04		2.59E+01			1.01E-02			3.01E-01	2.23E-05	3.01E-01
Nickel-59				1.39E-01			4.47E-08			1.49E-03	2.76E-08	1.49E-03
Nickel-63				4.93E+0			1.82E-01			6.70E-02	1.21E-06	6.70E-02
Strontium-90	1.07E-04	9.93E-04		3.61E-03			7.26E-04		1.50E-11	7.99E-02	1.34E-04	7.99E-02
Technetium-99				4.43E-06			8.10E-08			1.33E-05	3.03E-10	1.33E-05
Cesium-137	1.75E-04	6.89E-04	5.52E-14	6.96E-02			6.85E-02		5.38E-09	5.33E-02	2.15E-04	5.33E-02
Uranium-234	2.38E-08			9.73E-07			5.04E-05	2.32E-06	9.97E-08	4.44E-05	1.14E-06	4.44E-05
Uranium-235	8.41E-09			1.38E-05			2.28E-06	3.98E-07	3.00E-11	2.26E-06	5.29E-08	2.26E-06
Uranium-238	1.82E-08			5.95E-04	1.85E-04	1.57E-04	2.48E-05	2.50E-05	8.47E-08	1.03E-04	3.69E-06	1.03E-04

(a) BNL = Brookhaven National Laboratory   ORR = Oak Ridge Reservation
     GE Val = General Electric – Vallecitos   PNTX = Pantex Facility
     GJPO = Grand Junction Project Office   RFETS = Rocky Flats Environmental Technology Site
     INEEL = Idaho National Engineering and Environmental Laboratory   SNL = Sandia National Laboratories
     ITRI = Inhalation Toxicology Research Institute   SPRU = Separations Process Research Unit
     LLNL = Lawrence Livermore National Laboratory   WV = West Valley Nuclear Services

Table F.6. Stream 4 – TRU-RH Waste in Trenches

Constituent	Concentration	Units
Americium-241	6.35E+01	Ci/m^3
Plutonium-238	1.40E+01	Ci/m^3
Plutonium-239	5.51E+01	Ci/m^3
Plutonium-240	3.11E+01	Ci/m^3
Plutonium-241	1.20E+03	Ci/m^3
Beryllium	5.00E-01	kg/m^3
Sodium hydroxide	5.00E-01	kg/m^3
Xylene	4.80E+00	kg/m^3

Table F.7. Stream 4 – TRU-CH Waste in Trenches

Constituent	Concentration, Ci/m^3
Americium-241	2.63E-01
Plutonium-238	1.01E+00
Plutonium-239	5.67E-01
Plutonium-240	2.17E+01

Table F.8. Stream 5 – TRU-CH Waste in Caissons

Constituent	Concentration, Ci/m^3
Americium-241	5.55E+00
Cesium-137	5.06E+01
Cobalt-60	9.11E+00
Plutonium-238	8.98E-01
Plutonium-239	1.30E+01
Plutonium-240	3.26E+00
Plutonium-241	2.69E+01
Plutonium-242	1.26E-03
Strontium-90	4.67E+01
Uranium-233	1.04E-02
Uranium-234	1.30E-03
Uranium-235	3.91E-05
Uranium-238	9.57E-04

Table F.9. Stream 8 – TRU Waste Containing PCBs

Constituent	Concentration	Units
Americium-241	3.17E+00	Ci/m^3
Plutonium-238	7.21E-01	Ci/m^3
Plutonium-239	2.74E+00	Ci/m^3
Plutonium-240	1.54E+00	Ci/m^3
Plutonium-241	5.77E+01	Ci/m^3
Beryllium	5.00E-01	kg/m^3
Polychlorinated biphenyls (PCBs)	1.78E+00	kg/m^3
Sodium hydroxide	5.00E-01	kg/m^3
Xylene	4.80E+00	kg/m^3

Table F.10. Stream 9 – TRU-RH and -CH Drums and SWBs and Stream 10 – TRU-CH Boxes

Constituent	Concentration	Units
Americium-241	3.17E+00	Ci/m^3
Plutonium-238	7.21E-01	Ci/m^3
Plutonium-239	2.74E+00	Ci/m^3
Plutonium-240	1.54E+00	Ci/m^3
Plutonium-241	5.77E+01	Ci/m^3
Acetone	7.72E-04	kg/m^3
Beryllium	5.00E-01	kg/m^3
Carbon tetrachloride	1.33E-01	kg/m^3
Dichloromethane	5.72E-03	kg/m^3
Hydraulic fluid	2.31E-01	kg/m^3
Mercury	4.81E-03	kg/m^3
Sodium hydroxide	5.00E-01	kg/m^3
1,1,1-Trichloroethane	7.86E-04	kg/m^3
Xylene	4.05E-03	kg/m^3

Table F.11. Stream 10 – RH-TRU Waste Boxes

Constituent	Concentration	Units
Cesium-137	7.36E+00	Ci/m^3
Cobalt-60	3.13E-01	Ci/m^3
Iron-55	2.79E+00	Ci/m^3
Strontium-90	2.48E+00	Ci/m^3
Tritium	3.93E-03	Ci/m^3
Acetone	7.72E-04	kg/m^3
Beryllium	5.00E-01	kg/m^3
Carbon tetrachloride	1.33E-01	kg/m^3
Dichloromethane	5.72E-03	kg/m^3
Hydraulic fluid	2.31E-01	kg/m^3
Mercury	4.81E-03	kg/m^3
Sodium hydroxide	5.00E-01	kg/m^3
1,1,1-Trichloroethane	7.86E-04	kg/m^3
Xylene	4.05E-03	kg/m^3

Table F.12. Stream 11 – MLLW-Treated Ready for Disposal

Constituent	Concentration	Units
Americium-241	3.14E-05	Ci/m^3
Cesium-137	3.51E-03	Ci/m^3
Cobalt-60	6.33E-01	Ci/m^3
Curium-244	5.59E-04	Ci/m^3
Iron-55	1.14E-01	Ci/m^3
Neptunium-237	2.41E-06	Ci/m^3
Nickel-63	1.17E+0	Ci/m^3
Plutonium-238	2.91E-04	Ci/m^3
Plutonium-239	1.23E-04	Ci/m^3
Plutonium-240	2.14E-05	Ci/m^3
Plutonium-241	7.44E-04	Ci/m^3
Radium-224	1.68E-02	Ci/m^3
Strontium-90	1.05E-02	Ci/m^3
Tritium	3.93E-03	Ci/m^3

Constituent	Concentration	Units
Thorium-228	4.84E-05	Ci/m^3
Thorium-232	1.45E-06	Ci/m^3
Thorium-234	2.45E-02	Ci/m^3
Uranium-234	2.88E-04	Ci/m^3
Uranium-235	4.58E-06	Ci/m^3
Uranium-236	5.38E-06	Ci/m^3
Uranium-238	7.15E-05	Ci/m^3
Acetone	2.05E-01	kg/m^3
Beryllium	5.30E+00	kg/m^3
Bromodichloromethane	1.15E-03	kg/m^3
Carbon tetrachloride	4.18E-01	kg/m^3
Hydraulic fluid	3.63E-01	kg/m^3
Toluene	3.45E-01	kg/m^3
Formic acid	9.42E-01	kg/m^3
Dichloromethane	2.07E-01	kg/m^3
Diesel fuel	1.59E-01	kg/m^3
Methyl ethyl ketone (MEK)	1.60E-01	kg/m^3
Mercury	4.93E-02	kg/m^3
Nitric acid	6.70E+00	kg/m^3
Polychlorinated biphenyls (PCBs)	5.75E-01	kg/m^3
p-Chloroaniline	5.55E-01	kg/m^3
Sodium hydroxide	9.60E+00	kg/m^3
1,1,1-Trichloroethane	7.41 E-01	kg/m^3
Xylene	6.21E-02	kg/m^3

Table F.13. Stream 12 – MLLW-RH, and Large Boxes

Constituent	Concentration	Units
Cesium-137	7.36E+00	Ci/m^3
Cobalt-60	3.13E-01	Ci/m^3
Iron-55	2.79E+00	Ci/m^3
Strontium-90	2.48E+00	Ci/m^3
Tritium	3.93E-03	Ci/m^3
Acetone	2.00E-01	kg/m^3
Beryllium	5.30E+00	kg/m^3
Nitric acid	6.70E+00	kg/m^3
Sodium hydroxide	9.60E+00	kg/m^3
Toluene	1.06E+01	kg/m^3
Xylene	1.00E+00	kg/m^3

Table F.14. Stream 13 –MLLW-CH

Constituent	Concentration	Units
Americium-241	3.14E-05	Ci/m^3
Cesium-137	3.51E-03	Ci/m^3
Cobalt-60	6.33E-01	Ci/m^3
Curium-244	5.59E-04	Ci/m^3
Iron-55	1.14E-01	Ci/m^3
Nickel-63	1.17E+00	Ci/m^3
Neptunium-237	2.41E-06	Ci/m^3
Plutonium-238	2.91E-04	Ci/m^3
Plutonium-239	1.23E-04	Ci/m^3
Plutonium-240	2.14E-05	Ci/m^3
Plutonium-241	7.44E-04	Ci/m^3
Radium-224	1.68E-02	Ci/m^3
Strontium-90	1.05E-02	Ci/m^3
Thorium-228	4.84E-05	Ci/m^3
Thorium-232	1.45E-06	Ci/m^3
Thorium-234	2.45E-02	Ci/m^3

Table F.14. (contd)

Constituent	Concentration	Units
Tritium	3.93E-03	Ci/m^3
Uranium-234	2.88E-04	Ci/m^3
Uranium-235	4.58E-06	Ci/m^3
Uranium-236	5.38E-06	Ci/m^3
Uranium-238	7.15E-05	Ci/m^3
Acetone	2.05E-01	kg/m^3
Beryllium	5.30E+00	kg/m^3
Bromodichloromethane	1.15E-03	kg/m^3
Carbon tetrachloride	4.18E-01	kg/m^3
Dichloromethane	2.07E-01	kg/m^3
Diesel fuel	1.59E-01	kg/m^3
Formic acid	9.42E-01	kg/m^3
Hydraulic fluid	3.63E-01	kg/m^3
Methyl ethyl ketone (MEK)	1.60E-01	kg/m^3
Mercury	4.93E-02	kg/m^3
Nitrate	2.31E-01	kg/m^3
Nitric acid	6.70E+0	kg/m^3
Polychlorinated biphenyls (PCBs)	5.75E-01	kg/m^3
p-Chloroaniline	5.55E-01	kg/m^3
Sodium hydroxide	9.60E+00	kg/m^3
Toluene	3.45E-01	kg/m^3
1,1,1-Trichloroethane	7.41E-01	kg/m^3
Xylene	6.21E-02	kg/m^3

Table F.15. Stream 14 – Elemental Lead

Constituent	Concentration	Units
Americium-241	6.13E-05	Ci/m^3
Cerium-144	3.07E-03	Ci/m^3
Cesium-134	4.68E-05	Ci/m^3
Cesium-137	1.26E-02	Ci/m^3
Cobalt-60	1.24E-03	Ci/m^3
Neptunium-237	9.53E-07	Ci/m^3
Plutonium-238	9.30E-06	Ci/m^3
Plutonium-239	9.48E-05	Ci/m^3
Plutonium-240	4.06E-04	Ci/m^3
Plutonium-241	6.44E-04	Ci/m^3
Radium-224	4.17E-05	Ci/m^3
Radium-226	1.92E-04	Ci/m^3
Ruthenium-106	8.26E-04	Ci/m^3
Strontium-90	8.64E-03	Ci/m^3
Thorium-228	1.93E-03	Ci/m^3
Thorium-232	1.11E-06	Ci/m^3
Tritium	2.13E-05	Ci/m^3
Uranium-234	6.92E-06	Ci/m^3
Uranium-238	1.06E-05	Ci/m^3
Lead	9.80E+02	kg/m^3

Table F.16. Stream 15 – Elemental Mercury

Constituent	Concentration	Units
Americium-241	5.31E-06	Ci/m^3
Cerium-144	4.62E-04	Ci/m^3
Cesium-134	3.69E-06	Ci/m^3
Cesium-137	8.48E-04	Ci/m^3
Cobalt-60	4.60E-05	Ci/m^3
Plutonium-238	5.60E-06	Ci/m^3
Plutonium-239	2.70E-03	Ci/m^3
Plutonium-240	1.06E-05	Ci/m^3
Plutonium-241	4.06E-04	Ci/m^3
Ruthenium-106	1.62E-04	Ci/m^3
Strontium-90	1.18E-04	Ci/m^3
Thorium-232	1.27E-05	Ci/m^3
Tritium	6.98E-07	Ci/m^3
Mercury	1.34E+02	kg/m^3

Table F.17. Stream 17 – K Basin Sludge

Constituent	Concentration	Units
Americium-241	1.56E+01	Ci/m^3
Cesium-134	2.08E-01	Ci/m^3
Cesium-137	2.72E+02	Ci/m^3
Cobalt-60	5.47E-01	Ci/m^3
Neptunium-237	1.63E-03	Ci/m^3
Plutonium –238	2.68E+00	Ci/m^3
Plutonium-239	9.09E+00	Ci/m^3
Plutonium-240	5.02E+00	Ci/m^3
Strontium-90	2.73E+02	Ci/m^3
Technetium-99	4.17E-01	Ci/m^3
Uranium-234	3.39E-02	Ci/m^3
Uranium-235	1.18E-03	Ci/m^3
Uranium-236	3.97E-03	Ci/m^3
Uranium-238	2.53E-02	Ci/m^3
Polychlorinated biphenyls (PCBs)	1.63E-02	kg/m^3

Table F.18. Stream 18 – Leachate from MLLW Trenches

Constituent	Concentration, Ci/m^3
Americium-241	1.44E-11
Cesium-137	3.63E-11
Cobalt-60	6.54E-09
Curium-244	2.57E-10
Iron-55	1.18E-09
Neptunium-237	1.11E-12
Nickel-63	1.21E-08
Plutonium –238	1.34E-10
Plutonium-239	5.66E-11
Plutonium-240	9.84E-12
Plutonium-241	3.42E-10
Radium-224	7.73E-09
Strontium-90	1.09E-10
Thorium-228	2.06E-11
Thorium-232	6.67E-13
Thorium-234	1.13E-08
Tritium	4.06E-11
Uranium-234	1.32E-10
Uranium-235	2.11E-12
Uranium-236	2.47E-12
Uranium-238	3.29E-11

3

F.1.1.1 Release Fractions for Waste Receiving and Processing Facility

5

6   Potential releases from the WRAP have been characterized in the Notice of Construction (NOC)
7   reports for hazardous chemicals (DOE-RL 1993a) and radionuclides (DOE-RL 1993b). Release fractions
8   for radionuclides are based on 40 CFR 61, Appendix D (consistent with WAC 246-247). Releases of
9   particulate solids from the WRAP gloveboxes include a factor of 1E-03, with an additional 5E-07
10   reduction for double high-efficiency particulate air (HEPA) filtration efficiency. The net release fraction
11   is then 5E-10 for particulate material and 1.0 for volatile radionuclides (such as tritium and carbon-14).

12

13   Release fractions for non-radioactive volatile organic compounds (VOCs) were based on the vapor
14   pressure and molecular weight of the chemical (DOE-RL 1993a, Appendix A). The releases were
15   postulated to occur when a container was opened (within a glovebox) and the volatile chemicals were

1   emptied onto a holding pan with a diameter of 0.5 m (1.6 ft). The theoretical vaporization rate from this
2   geometry was used to estimate the release rate over a one-year period. If the theoretical release rate
3   indicated a greater release than the total inventory processed in a year, the chemical was assumed to be
4   totally released (release fraction is 1.0).
5
6   The analysis presented in the WRAP NOC included consideration of the total mass fraction of each
7   chemical in the annual processing inventory. A similar approach was used in the current analysis, except
8   the mass fraction was set to 1.0, representing a case where the chemical is the only one in the container
9   emptied onto the holding pan. Also, the WRAP NOC analysis assumed the chemical would remain on
10 the holding pan for the entire year. In the current analysis, the time was set to one day, and the theoretical
11 release was divided by the amount of the chemical in one drum (average value). This process is in
12 contrast to the NOC analysis that compared the release over a year to the total amount processed in a year.
13 The net difference in the two analyses is the current analysis is based on one drum, and the NOC analysis
14 is based on a year of operation. The current analysis was based on one drum because the processing rates
15 may change for each alternative and the analysis could be performed in a more straightforward manner if
16 the processing rate were not involved in the release fraction estimation. A summary of the release
17 fraction evaluation for the WRAP is shown in Table F.19. The release fraction for volatile chemicals
18 indicates the dependence on physical properties. Gases represent chemicals that have a vapor pressure
19 above one atmosphere at ambient conditions.
20
21   Release fractions for specific VOCs are presented in Table F.20. As previously discussed, the release
22 fraction is dependent on the waste stream because the release is based on the total amount of a chemical
23 in one drum. The release fractions are based on total glovebox throughput of the waste type in the
24 WRAP. For example, if a waste stream of transuranic (TRU) waste is defined as going to the gloveboxes,
25 the release fraction does not include the processing fraction (0.1) and the release fraction for most VOCs
26 would be 1.0. If the throughput is defined as the amount going to the WRAP, the release fraction must
27 include the processing fraction (0.1). The processing fraction is multiplied by the listed release fraction of
28 Table F.20 to find the correct release fraction for total throughput of the WRAP.
29
30   **Table F.19**. Release Fraction Values for the WRAP
31

Constituents Type	Form	Release Fraction
Radioactive material	Gases	1.0
	Particulates	5E-10
Chemicals	Gases	1.0
	VOCs [a]	0.12 VM/drum amount [b]
	Inorganic chemicals	5E-10
(a) VOCs = volatile organic compounds. (b) Average amount in one drum expressed in kg/drum, vapor pressure (V) in atmospheres, and molecular weight (M) in g. The release fraction is limited to a maximum value of 1.0.		

32

Table F.20. Release Fractions for Volatile Organic Compounds from the WRAP

Chemical Name	Waste Stream Description	
	TRU Waste, New and Stored	MLLW
1,1,1-Trichloroethane	1.0	1.0
Acetone	1.0	1.0
Bromodichloromethane	1.0	1.0
Carbon tetrachloride	1.0	1.0
p-chloroaniline	1.0	2.6E-03
Dichloromethane	--	1.0
Diesel fuel	--	3.4E-02
Formic acid	1.0	1.0
Hydraulic fluid	1.1E-04	7.5E-05
Mercury	6.4E-02	6.3E-03
Methyl ethyl ketone (MEK)	1.0	1.0
Polychlorinated biphenyls (PCBs)	4.0E-05	3.0E-05
Toluene	1.0	1.0
Xylene	1.0	1.0

The total estimated releases from the WRAP for each alternative are given in Tables F.21 and F.22 for radionuclides and chemicals, respectively. The tables present releases for the Lower Bound and Upper Bound waste volumes for Alternative Groups A and B. The releases of radionuclides for the Hanford Only volume are just slightly smaller than those for the Lower Bound volume and are not shown. For chemicals, the releases for the Hanford Only waste volume are essentially identical to the Lower Bound volume because processing of MLLW for the two cases is nearly identical. The releases for Alternative Groups C, D, and E are essentially the same as those for Alternative Group A and are not shown.

F.1.1.2 Release Fractions for the Existing T Plant Complex

The release fractions are based on the value in 40 CFR 61, Appendix D (consistent with WAC 246-247), for particulate and solid contamination modified to include HEPA filtration. The 2706-T facility has single HEPA filtration and 221-T has double HEPA filtration. The HEPA filtration efficiency for the 2706-T single HEPA filter is set to 99.95 percent. The analyses for releases from the existing T Plant Complex are based on all processing being done in the 2706-T facility. A summary of the release fractions for the T Plant Complex is given in Table F.23. The release fractions for specific VOCs are the same as for the WRAP (see Table F.20).

1 **Table F.21**. Airborne Radionuclide Releases from the WRAP
2

| Radionuclide | Total Release, Ci | | | | |
| | Alternative Group A | | Alternative Group B | | |
	Lower Volumes	Upper Volumes	Lower Volumes	Upper Volumes	No Action
Americium-241	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06
Cesium-137	1.9E-08	1.3E-07	1.9E-08	2.2E-08	1.9E-08
Cobalt-60	1.2E-08	9.3E-08	1.2E-08	9.3E-08	1.2E-08
Curium-244	3.5E-11	2.0E-10	3.5E-11	2.0E-10	3.5E-11
Iron-55	7.1E-10	4.4E-09	7.1E-10	4.4E-09	7.1E-10
Manganese-54	1.3E-13	1.3E-13	1.3E-13	1.3E-13	1.3E-13
Nickel-63	1.1E-07	6.3E-07	1.1E-07	6.3E-07	1.1E-07
Neptunium-237	2.6E-13	1.4E-12	2.6E-13	1.4E-12	2.6E-13
Plutonium-238	6.9E-07	6.9E-07	6.9E-07	6.9E-07	6.9E-07
Plutonium-239	2.9E-06	2.9E-06	2.9E-06	2.9E-06	2.9E-06
Plutonium-240	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06
Plutonium-241	3.3E-05	3.3E-05	3.3E-05	3.3E-05	3.3E-05
Radium-224	2.4E-13	1.2E-12	2.4E-13	1.2E-12	2.4E-13
Strontium-90	2.4E-08	1.7E-07	2.4E-08	2.8E-08	2.4E-08
Thorium-234	1.0E-10	6.2E-10	1.0E-10	1.4E-10	1.0E-10
Tritium	1.4E+02	2.7E+02	1.4E+02	2.7E+02	1.4E+02
Uranium-234	1.2E-10	5.5E-10	1.2E-10	2.5E-10	1.2E-10
Uranium-235	2.2E-12	1.7E-11	2.2E-12	8.3E-12	2.2E-12
Uranium-236	8.3E-12	4.9E-11	8.3E-12	1.1E-11	8.3E-12
Uranium-238	1.0E-10	6.2E-10	1.0E-10	1.4E-10	1.0E-10

3
4   The total estimated releases from the T Plant Complex for the alternative groups are shown in
5 Tables F.24 and F.25 for radionuclides and chemicals, respectively. The releases shown for Alternative
6 Group A are for wastes processed in existing facilities and do not include releases in the modified T Plant.
7 The later releases are described in the next section. The tables present releases for the Lower Bound and
8 Upper Bound waste volumes for Alternative Groups A and B. The releases of radionuclides for the
9 Hanford Only waste volume are just slightly smaller than those for the Lower Bound volume and are not
10 shown. For chemicals, the releases for the Hanford Only volume are essentially identical to the Lower
11 Bound volume because processing of MLLW for the two waste volumes is nearly identical. The releases
12 for Alternative Groups C, D, and E are essentially the same as those for Alternative Group A and are not
13 shown.

Table F.22. Total Chemical Atmospheric Releases from the WRAP

| Chemical Name | Total Release, kg | | | | |
| | Alternative Group A | | Alternative Group B | | |
	Lower Volumes	Upper Volumes	Lower Volumes	Upper Volumes	No Action
Acetone	4.5E+01	2.3E+02	4.5E+01	2.3E+02	4.5E+01
Beryllium	7.7E-07	3.2E-06	7.7E-07	3.2E-06	7.7E-07
Bromodichloromethane	2.5E-01	1.3E+0	2.5E-01	1.3E+0	2.5E-01
Carbon tetrachloride	1.9E+02	5.7E+02	1.9E+02	5.7E+02	1.9E+02
Dichloromethane	4.9E+01	2.4E+02	4.9E+01	2.4E+02	4.9E+01
Diesel fuel	1.2E+0	6.1E+0	1.2E+0	6.1 E+0	1.2E+0
Formic acid	2.0E+02	1.1E+03	2.0E+02	1.1E+03	2.0E+02
Hydraulic fluid	2.6E-02	5.0E-02	2.6E-02	4.9E-02	2.6E-02
Mercury (elemental)	3.1E-01	5.9E-01	3.1E-01	5.7E-01	3.1E-01
Methyl ethyl ketone (MEK)	3.4E+01	1.8E+02	3.4E+01	1.8E+02	3.4E+01
Nitrate	2.3E-08	2.3E-08	2.3E-08	2.3E-08	2.3E-08
Nitric acid	7.2E-07	3.8E-06	7.2E-07	3.8E-06	7.2E-07
Polychlorinated biphenyls (PCBs)	3.8E-03	1.9E-02	3.7E-03	1.9E-02	3.7E-03
p-chloroaniline	3.1E-01	1.6E+00	3.1E-01	1.6E+00	3.1E-01
Sodium hydroxide	1.2E-06	5.6E-06	1.2E-06	5.6E-06	1.2E-06
Toluene	7.4E+01	3.9E+02	7.4E+01	3.9E+02	7.4E+01
1,1,1-Trichloroethane	1.6E+02	8.3E+02	1.6E+02	8.3E+02	1.6E+02
Xylene	1.6E+01	7.3E+01	1.6E+01	7.3E+01	1.6E+01

Table F.23. Release Fraction Values for the 2706-T Facility in the T Plant Complex

Operation	Form	Release Fraction	Filter Factor	Net Release Fraction
2706-T Facility	Gases	1E+00	1E+00	1E+00
	Particulates	1E-03	5E-04	5E-07
	Solids	1E-06	5E-04	5E-10

1
2

Table F.24. Total Radionuclide Atmospheric Release from the T Plant Complex

| | Total Release, Ci | | | | |
| | Alternative Group A | | Alternative Group B | | |
Radionuclide	Lower Volumes	Upper Volumes	Lower Volumes	Upper Volumes	No Action
Americium-241	8.8E-07	8.9E-07	8.8E-07	8.9E-07	8.8E-07
Cesium-137	4.5E-04	4.6E-04	4.5E-04	4.6E-04	4.5E-04
Cobalt-60	4.2E-06	5.4E-05	4.2E-06	5.4E-05	4.2E-06
Curium-244	4.6E-08	1.0E-07	4.6E-08	1.0E-07	4.6E-08
Iron-55	2.6E-07	1.5E-06	2.6E-07	1.5E-06	2.6E-07
Manganese-54	4.1E-10	4.1E-10	4.1E-10	4.1E-10	4.1E-10
Neptunium-237	8.7E-11	4.5E-10	8.7E-11	4.5E-10	8.7E-11
Nickel-63	3.8E-05	2.7E-04	3.8E-05	2.7E-04	3.8E-05
Plutonium-238	1.3E-07	1.7E-07	1.3E-07	1.7E-07	1.3E-07
Plutonium-239	7.0E-07	7.2E-07	7.0E-07	7.2E-07	7.0E-07
Plutonium-240	2.7E-07	2.8E-07	2.7E-07	2.8E-07	2.7E-07
Plutonium-241	6.5E-06	6.6E-06	6.5E-06	6.6E-06	6.5E-06
Strontium-90	5.7E-04	5.7E-04	5.7E-04	5.7E-04	5.7E-04
Thorium-228	8.1E-11	4.1E-10	8.1E-11	4.1E-10	8.1E-11
Thorium-232	5.2E-11	2.7E-10	5.2E-11	2.7E-10	5.2E-11
Thorium-234	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06
Tritium	6.4E+02	1.1E+03	6.4E+02	1.1E+03	6.4E+02
Uranium-234	1.4E-06	1.4E-06	1.4E-06	1.4E-06	1.4E-06
Uranium-235	4.0E-08	4.1E-08	4.0E-08	4.1E-08	4.0E-08
Uranium-236	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07
Uranium-238	2.2E-06	2.2E-06	2.2E-06	2.2E-06	2.2E-06

Table F.25. Total Chemical Atmospheric Releases from the T Plant Complex

| Chemical Name | Total Release, kg | | | | |
| | Alternative Group A | | Alternative Group B | | |
	Lower Bound Volumes	Upper Bound Volumes	Lower Bound Volumes	Upper Bound Volumes	No Action
Acetone	1.5E+01	7.7E+01	1.5E+01	7.6E+01	1.5E+01
Beryllium	1.9E-04	9.9E-04	1.9E-04	9.8E-04	1.3E-05
Bromodichloromethane	8.3E-02	4.3E-01	8.3E-02	4.3E-01	8.3E-02
Carbon tetrachloride	3.0E+01	1.6E+02	3.0E+01	1.6E+02	3.0E+01
Dichloromethane	1.5E+01	7.8E+01	1.5E+01	7.7E+01	1.5E+01
Diesel fuel	3.9E-01	2.0E+00	3.9E-01	2.0E+00	3.9E-01
Formic acid	6.8E+01	3.5E+02	6.8E+01	3.5E+02	6.8E+01
Hydraulic fluid	2.0E-03	1.0E-02	2.0E-03	1.0E-02	2.0E-03
Mercury (elemental)	2.2E-02	1.2E-01	2.2E-02	1.2E-01	2.2E-02
Methyl ethyl ketone (MEK)	1.2E+01	6.0E+01	1.2E+01	5.9E+01	1.2E+01
Nitrate	7.8E-06	7.8E-06	7.8E-06	7.8E-06	7.8E-06
Nitric acid	2.4E-04	1.3E-03	2.4E-04	1.2E-03	1.6E-05
Polychlorinated biphenyls (PCBs)	1.2E-03	6.5E-03	1.2E-03	6.4E-03	1.2E-03
p-chloroaniline	1.0E-01	5.4E-01	1.0E-01	5.3E-01	1.0E-01
Sodium hydroxide	3.5E-04	1.8E-03	3.5E-04	1.8E-03	2.3E-05
Toluene	2.5E+01	1.3E+02	2.5E+01	1.3E+02	2.5E+01
1,1,1-Trichloroethane	5.3E+01	2.8E+02	5.3E+01	2.7E+02	5.3E+01
Xylene	4.5E+00	2.3E+01	4.5E+00	2.3E+01	4.5E+00
(a) PCBs = polychlorinated biphenyls.					

F.1.1.3 The New Waste Processing Facility and Modified T Plant Complex

The handling of wastes in the new waste processing facility and the modified T Plant Complex would be conducted in a manner similar to that in the WRAP except that some operations would be performed remotely. Therefore, the release fractions applicable to the WRAP were also used to estimate releases from waste processed in the new waste processing facility and the modified T Plant Complex. Double HEPA filtration was assumed for these facilities. Because some mixed waste may be processed in these facilities, the release fractions for hazardous chemicals are also needed. The release fractions are summarized in Table F.26. The release fractions for specific VOCs are the same as those presented for the WRAP (see Table F.20).

Table F.26. Release Fraction Values for the New Waste Processing Facility and the Modified T Plant Complex

Constituent Type	Form	Release Fraction
Radioactive material	Gases	1E+0
	Particulates	5E-10
Chemicals	Gases	1E+00
	VOCs[a]	0.12VM/drum amount[b]
	Inorganic chemicals	5E-10
(a) VOCs = volatile organic compounds.		
(b) Average amount in one drum expressed in kg/drum, vapor pressure (V) is in atmospheres and molecular weight (M) is in g. The release fraction is limited to a maximum value of 1.0.		

The total estimated releases from the modified T Plant Complex for Alternative Group A are given in Tables F.27 and F.28 for radionuclides and chemicals, respectively. Total releases of radionuclides for the new waste processing facility for Alternative Group B are shown in Table F.29. Chemical releases for the new waste processing facility for Alternative Group B are shown in Table F.30. Releases are estimated to be the same for the Lower and Upper Bound waste volume estimates because waste streams processing in these facilities are the same for both options. The releases for Alternative Groups C, D, and E are essentially the same as those for Alternative Group A and are not shown.

Table F.27. Total Radionuclide Atmospheric Release from the Modified T Plant Complex for Alternative Group A (both Lower Bound and Upper Bound Waste Volumes)

Radionuclide	Total Release, Ci
Americium-241	3.1E-04
Cesium-134	4.2E-11
Cesium-137	2.3E-05
Cobalt-60	3.8E-08
Iron-55	1.3E-08
Plutonium-238	4.0E-05
Plutonium-239	1.9E-04
Plutonium-240	1.1E-04
Plutonium-241	1.2E-03
Strontium-90	1.6E-05
Technicium-99	2.9E-08
Tritium	4.4E+02
Uranium-234	5.7E-09
Uranium-235	8.3E-11
Uranium-236	2.8E-10
Uranium-238	1.8E-09

1 **Table F.28**. Total Chemical Atmospheric Releases from the Modified
2   T Plant Complex for Alternative Group A
3

Chemical Name	Total Release, kg
Acetone	5.8E+02
Beryllium	1.0E-05
Carbon tetrachloride	4.3E+02
Dichloromethane	1.9E+01
Hydraulic fluid	8.3E-02
Mercury (elemental)	1.0E+00
Nitric acid	9.7E-06
Polychlorinated biphenyls (PCBs)	6.8E-03
Sodium hydroxide	1.6E-05
Toluene	3.1E+04
1,1,1-Trichloroethane	2.6E+00
Xylene	3.7E+04

4
5 **Table F.29**. Atmospheric Radionuclide Releases from the New
6   Waste Processing Facility for Alternative Group B
7

Radionuclide	Total Release, Ci
Americium-241	2.3E-04
Cerium-144	5.9E-15
Cesium-134	7.9E-12
Cesium-137	1.8E-05
Cobalt-60	1.0E-06
Curium-244	4.8E-09
Iron-55	2.9E-08
Neptunium-237	1.6E-10
Plutonium-238	2.9E-05
Plutonium-239	1.4E-04
Plutonium-240	8.1E-05
Plutonium-241	7.7E-04
Strontium-90	1.4E-05
Technicium-99	2.9E-08
Thorium-234	3.1E-09
Tritium	5.1E+01
Uranium-234	1.0E-08
Uranium-235	1.7E-10
Uranium-236	3.7E-10
Uranium-238	3.1E-09

1 **Table F.30**. Total Chemical Atmospheric Releases from the New
2   Waste Processing Facility for Alternative Group B
3

Chemical Name	Total Release, kg
Acetone	7.9E+03
Beryllium	1.0E-04
Bromodichloromethane	4.2E+01
Carbon tetrachloride	4.3E+02
Dichloromethane	7.5E+03
Diesel Fuel	2.0E+02
Formic Acid	3.4E+04
Hydraulic fluid	1.0E+03
Lead	4.8E-04
Mercury (elemental)	4.2E+01
Methyl ethyl ketone (MEK)	5.8E+03
Nitrate	4.2E-06
Nitric acid	1.3E-04
Polychlorinated biphenyls (PCBs)	6.3E-01
p-chloroaniline	5.2E+01
Sodium hydroxide	1.8E-04
Toluene	3.4E+04
1,1,1-Trichloroethane	2.7E+04
Xylene	4.6E+03

4
5 **F.1.1.4 Pulse Drier Operation**
6
7   The treatment of trench leachate would be performed in the Effluent Treatment Facility until that
8 facility is decommissioned in 2025. Starting in 2026, the plan is to treat leachate using pulse driers
9 installed near the trenches. Releases from drier operations are estimated using a release fraction of 0.001
10 (40 CFR 61, Appendix D) and a HEPA filtration factor of 5E-04. The net release fraction of 5E-07 is
11 applied to radionuclides in the leachate from the trenches except for tritium and carbon-14, which are
12 assumed to be totally released. The leachate is not expected to contain substantial amounts of volatile
13 hazardous chemicals. The total annual release from leachate treatment using pulse driers is given in
14 Table F.31 for Alternative Groups A and B. Releases for Alternative Groups C and D and for the No
15 Action Alternative are given in Table F.32. Releases for Alternative Group E are expected to be the same
16 as those for Alternative Group D.

1 **Table F.31**. Atmospheric Radionuclide Release from Pulse Drier Leachate Treatment: Alternative
2 Groups A and B
3

Radionuclide	Total Release, Ci					
	Alternative Group A			Alternative Group B		
	Hanford Only	Lower Volumes	Upper Volumes	Hanford Only	Lower Volumes	Upper Volumes
Americium-241	4.6E-13	1.1E-12	1.5E-12	3.4E-12	4.0E-12	6.7E-12
Cesium-137	3.0E-13	6.8E-13	9.9E-13	2.2E-12	2.6E-12	4.3E-12
Cobalt-60	9.8E-13	2.3E-12	3.3E-12	7.3E-12	8.5E-12	1.4E-11
Curium-244	1.2E-12	2.7E-12	3.9E-12	8.7E-12	1.0E-11	1.7E-11
Iron-55	2.5E-15	5.7E-15	8.2E-15	1.8E-14	2.1E-14	3.6E-14
Neptunium-237	2.2E-14	5.1E-14	7.5E-14	1.7E-13	1.9E-13	3.3E-13
Nickel-63	1.8E-10	4.2E-10	6.1E-10	1.4E-09	1.6E-09	2.7E-09
Plutonium-238	2.0E-12	4.5E-12	6.6E-12	1.5E-11	1.7E-11	2.9E-11
Plutonium-239	1.1E-12	2.6E-12	3.8E-12	8.5E-12	9.9E-12	1.7E-11
Plutonium-240	2.1E-13	4.8E-13	7.0E-13	1.6E-12	1.8E-12	3.0E-12
Plutonium-241	1.1E-12	2.5E-12	3.6E-12	7.9E-12	9.3E-12	1.6E-11
Strontium-90	8.6E-13	2.0E-12	2.9E-12	6.4E-12	7.5E-12	1.3E-11
Tritium	1.9E-07	4.3E-07	6.3E-07	1.4E-06	1.6E-06	2.7E-06
Uranium-234	2.7E-12	6.1E-12	8.9E-12	2.0E-11	2.3E-11	3.9E-11
Uranium-235	4.2E-14	9.8E-14	1.4E-13	3.2E-13	3.7E-13	6.2E-13
Uranium-236	5.0E-14	1.1E-13	1.7E-13	3.7E-13	4.3E-13	7.2E-13
Uranium-238	6.6E-13	1.5E-12	2.2E-12	4.9E-12	5.8E-12	9.6E-12

1 **Table F.32**. Atmospheric Radionuclide Release from Pulse Drier Leachate Treatment: Alternative
2   Groups C and D, and the No Action Alternative
3

Radionuclide	Total Release, Ci						
	Alternative Group C			Alternative Group D			
	Hanford Only	Lower Volumes	Upper Volumes	Hanford Only	Lower Volumes	Upper Volumes	No Action
Americium-241	4.6E-13	4.8E-13	9.6E-13	1.2E-12	1.3E-12	3.0E-12	1.5E-13
Cesium-137	3.0E-13	3.1E-13	6.2E-13	7.6E-13	8.4E-13	1.9E-12	1.2E-13
Cobalt-60	9.8E-13	1.0E-12	2.1E-12	2.5E-12	2.8E-12	6.3E-12	5.8E-13
Curium-244	1.2E-12	1.2E-12	2.4E-12	3.0E-12	3.3E-12	7.5E-12	4.9E-13
Iron-55	2.5E-15	2.6E-15	5.1E-15	6.3E-15	7.0E-15	1.6E-14	1.8E-15
Neptunium-237	2.2E-14	2.3E-14	4.7E-14	5.7E-14	6.4E-14	1.4E-13	7.6E-15
Nickel-63	1.8E-10	1.9E-10	3.8E-10	4.7E-10	5.2E-10	1.2E-09	6.5E-11
Plutonium –238	2.0E-12	2.1E-12	4.1E-12	5.1E-12	5.6E-12	1.3E-11	7.0E-13
Plutonium-239	1.1E-12	1.2E-12	2.4E-12	2.9E-12	3.3E-12	7.3E-12	3.9E-13
Plutonium-240	2.1E-13	2.2E-13	4.3E-13	5.3E-13	5.9E-13	1.3E-12	7.0E-14
Plutonium-241	1.1E-12	1.1E-12	2.2E-12	2.7E-12	3.1E-12	6.9E-12	4.7E-13
Strontium-90	8.6E-13	9.0E-13	1.8E-12	2.2E-12	2.5E-12	5.6E-12	3.3E-13
Tritium	1.9E-07	2.0E-07	3.9E-07	4.8E-07	5.4E-07	1.2E-06	8.5E-08
Uranium-234	2.7E-12	2.8E-12	5.6E-12	6.8E-12	7.6E-12	1.7E-11	9.0E-13
Uranium-235	4.2E-14	4.4E-14	8.9E-14	1.1E-13	1.2E-13	2.7E-13	1.4E-14
Uranium-236	5.0E-14	5.2E-14	1.0E-13	1.3E-13	1.4E-13	3.2E-13	1.7E-14
Uranium-238	6.6E-13	6.9E-13	1.4E-12	1.7E-12	1.9E-12	4.3E-12	2.2E-13

4
5 ## F.1.2   Release Point Characteristics
6
7   The atmospheric transport analysis requires definition of release point characteristics for each facility
8 that has a release to air. The characteristics are presented in Table F.33 for the WRAP, 2706-T facility,
9 the modified T Plant Complex, and pulse driers. Values for the WRAP are taken from the NOC
10 (DOE-RL 2001); for the 2706-T facility from the Interim Safety Analysis for T Plant (Meyer 1998); for
11 the modified T Plant Complex from the NOC (DOE-RL 2000) and Rokkan et al. (2001). Pulse drier
12 characteristics are from the Technical Information Document (FH 2003). For all facilities, the
13 temperature of outside air is set to the annual average value of 12°C (53.6°F).

Table F.33. Release Point Characteristics

Parameter	Units	WRAP and New Waste Processing Facility	2706-T Facility	Modified T Plant Complex	Pulse Driers
Stack height	M	14	8.5	61	5
Exit area	m^2	0.5	0.39	1.8	0.20
Exit velocity	m/s	15.4	15[a]	8.3	1.5
Exit air temperature	°C	32.2	25.6	23.9	74
Height of building	M	7	7.62	25	4.3
(a) The average exit velocity was set to one half the maximum value for the 2706-T facility.					

F.1.3 Atmospheric Transport

The transport and deposition of material released to the atmosphere was evaluated using the atmospheric transport component of MEPAS Version 4.0. This component implements the models from earlier versions of MEPAS, as described by Droppo and Buck (1996). The models are similar to and consistent with the models recommended by EPA in the Industrial Source Complex dispersion model (EPA 1995). Also, the atmospheric dispersion models in the MEPAS program provide nearly identical results to those generated using the EPA CAP88 program, as verified in a benchmarking study performed on the MEPAS, MMSOILS, and RESRAD computer programs (Mills et al. 1997). The RESRAD program uses the CAP88 program for atmospheric transport calculations (Cheng et al. 1995).

The MEPAS model uses a data set of the annual joint frequency of occurrence of wind speed, wind direction, and atmospheric stability from the 200 Area Hanford Meteorology Station. The data set used for the present analysis was the 14-year average for the years 1983 through 1996 (Hoitink and Burk 1997) as presented in Tables F.34 and F.35. This data set is used in the atmospheric transport and deposition model to evaluate the air concentration and deposition rate as a function of direction and downwind distance. The pollutant concentrations in air and deposition rates are expressed as annual average values. The annual joint frequency data set is based on heights of 9.1 m (30 ft) and 60 m (197 ft) for Tables F.34 and F.35, respectively. The MEPAS code adjusts the data to represent the actual release height defined in Table F.33.

The population dose values were estimated from the calculated individual doses by multiplying by a conversion factor relating the population weighted χ/Q value to the χ/Q value at the location of the offsite MEI (7E+04 person-s/m^3). This conversion factor was also used to estimate population health impacts from carcinogenic chemicals. The population distribution (Beck et al. 1991) is given in Table F.36.

Table F.34. Joint Frequency Distributions for the 200 Areas at 9.1-m (30-ft) Towers, 1983-1996 Historical Data

Average Wind Speed (m/s)	Atmospheric Stability Class	Percentage of Time Wind Blows from the 200 Area Toward the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.28	0.31	0.34	0.25	0.23	0.22	0.18	0.13	0.11	0.1	0.08	0.07	0.1	0.1	0.16	0.21
	B	0.14	0.15	0.16	0.11	0.11	0.09	0.08	0.05	0.05	0.04	0.04	0.04	0.05	0.07	0.09	0.12
	C	0.15	0.15	0.14	0.1	0.09	0.09	0.09	0.06	0.04	0.04	0.05	0.05	0.06	0.07	0.1	0.13
	D	0.87	0.76	0.72	0.55	0.6	0.65	0.64	0.42	0.36	0.31	0.35	0.38	0.49	0.59	0.77	0.83
	E	0.4	0.29	0.27	0.26	0.3	0.35	0.46	0.41	0.36	0.35	0.44	0.49	0.55	0.66	0.65	0.57
	F	0.25	0.16	0.15	0.15	0.15	0.2	0.25	0.24	0.26	0.29	0.35	0.36	0.43	0.45	0.42	0.33
	G	0.1	0.09	0.1	0.07	0.08	0.08	0.1	0.1	0.1	0.1	0.14	0.11	0.14	0.15	0.17	0.15
2.65	A	0.64	0.45	0.35	0.32	0.35	0.37	0.34	0.23	0.17	0.2	0.27	0.2	0.17	0.26	0.6	0.7
	B	0.26	0.17	0.11	0.1	0.1	0.12	0.1	0.07	0.06	0.06	0.09	0.07	0.07	0.14	0.29	0.31
	C	0.22	0.13	0.1	0.08	0.08	0.09	0.1	0.05	0.05	0.05	0.06	0.06	0.06	0.1	0.25	0.28
	D	0.64	0.46	0.3	0.27	0.31	0.36	0.43	0.29	0.23	0.24	0.3	0.39	0.55	1.05	1.72	1.12
	E	0.29	0.16	0.11	0.1	0.21	0.28	0.35	0.41	0.31	0.29	0.53	0.98	1.68	2.09	1.71	0.77
	F	0.15	0.07	0.05	0.06	0.09	0.11	0.3	0.33	0.31	0.37	0.65	1.23	1.74	1.89	1.57	0.59
	G	0.04	0.03	0.02	0.02	0.04	0.04	0.13	0.18	0.19	0.2	0.32	0.65	0.68	0.78	0.69	0.19
4.7	A	0.19	0.22	0.11	0.04	0.04	0.03	0.04	0.04	0.05	0.13	0.31	0.36	0.21	0.23	0.61	0.3
	B	0.04	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.04	0.06	0.1	0.08	0.09	0.22	0.09
	C	0.04	0.03	0.02	0.01	0	0	0.01	0.01	0.02	0.04	0.05	0.08	0.07	0.08	0.2	0.09
	D	0.14	0.13	0.06	0.04	0.05	0.04	0.07	0.09	0.11	0.19	0.34	0.52	0.57	1.11	1.45	0.37
	E	0.07	0.06	0.04	0.02	0.02	0.02	0.06	0.1	0.11	0.15	0.37	0.66	1.09	1.95	1.78	0.25
	F	0.02	0.01	0.01	0.01	0.01	0.01	0.04	0.09	0.04	0.03	0.08	0.3	0.33	0.53	0.72	0.11
	G	0	0	0	0	0	0	0.02	0.04	0.01	0.02	0.04	0.18	0.1	0.16	0.32	0.03
7.15	A	0.03	0.06	0.04	0.01	0	0	0.01	0.01	0.02	0.06	0.23	0.33	0.15	0.17	0.44	0.11
	B	0.01	0.01	0.01	0	0	0	0	0	0.01	0.03	0.06	0.08	0.03	0.05	0.12	0.02
	C	0.01	0.01	0.01	0	0	0	0	0	0.01	0.02	0.04	0.07	0.03	0.03	0.08	0.02
	D	0.03	0.05	0.03	0.01	0	0	0.01	0.03	0.06	0.16	0.38	0.35	0.24	0.6	0.85	0.11
	E	0.01	0.05	0.02	0	0	0	0	0.02	0.05	0.11	0.25	0.23	0.15	0.47	0.93	0.06
	F	0	0	0	0	0	0	0	0.01	0	0	0.01	0.02	0.01	0.01	0.02	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table F.35. Joint Frequency Distributions for the 200 Areas at 60-m (197-ft) Aboveground Level, 1983-1996 Historical Data

Average Wind Speed m/s	Atmospheric Stability Class	Percentage of Time Wind Blows from the 200 Area Toward the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.89	A	0.11	0.13	0.15	0.11	0.11	0.12	0.07	0.05	0.03	0.02	0.04	0.03	0.05	0.03	0.05	0.07
	B	0.09	0.09	0.08	0.07	0.07	0.06	0.06	0.03	0.02	0.03	0.02	0.02	0.02	0.03	0.05	0.07
	C	0.09	0.08	0.1	0.08	0.07	0.06	0.06	0.04	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.08
	D	0.58	0.53	0.51	0.43	0.45	0.49	0.52	0.35	0.24	0.22	0.22	0.2	0.27	0.35	0.44	0.54
	E	0.29	0.22	0.2	0.18	0.22	0.28	0.32	0.25	0.18	0.17	0.17	0.17	0.23	0.25	0.31	0.32
	F	0.2	0.13	0.12	0.11	0.14	0.14	0.19	0.14	0.13	0.12	0.13	0.12	0.17	0.19	0.23	0.21
	G	0.07	0.05	0.05	0.05	0.06	0.07	0.1	0.07	0.07	0.06	0.08	0.09	0.09	0.11	0.12	0.1
2.65	A	0.61	0.5	0.46	0.41	0.43	0.41	0.43	0.3	0.2	0.18	0.18	0.17	0.12	0.16	0.43	0.58
	B	0.25	0.2	0.16	0.12	0.14	0.13	0.12	0.1	0.07	0.06	0.07	0.05	0.06	0.09	0.22	0.27
	C	0.23	0.16	0.13	0.09	0.1	0.1	0.12	0.07	0.05	0.06	0.06	0.05	0.04	0.08	0.21	0.28
	D	0.79	0.56	0.39	0.32	0.39	0.37	0.5	0.34	0.22	0.23	0.24	0.25	0.35	0.63	1.29	1.1
	E	0.37	0.23	0.18	0.16	0.22	0.23	0.34	0.34	0.18	0.18	0.25	0.34	0.5	0.8	0.95	0.66
	F	0.28	0.13	0.11	0.08	0.1	0.12	0.22	0.23	0.18	0.17	0.23	0.3	0.53	0.79	0.81	0.6
	G	0.09	0.05	0.04	0.03	0.04	0.03	0.08	0.11	0.1	0.1	0.13	0.19	0.33	0.41	0.32	0.23
4.7	A	0.32	0.29	0.18	0.08	0.08	0.06	0.09	0.09	0.09	0.15	0.28	0.27	0.14	0.19	0.64	0.41
	B	0.09	0.08	0.04	0.03	0.03	0.02	0.02	0.03	0.03	0.04	0.08	0.09	0.05	0.09	0.28	0.15
	C	0.06	0.05	0.03	0.02	0.02	0.01	0.02	0.02	0.02	0.04	0.05	0.07	0.05	0.07	0.21	0.13
	D	0.2	0.16	0.09	0.06	0.08	0.08	0.13	0.14	0.12	0.16	0.26	0.31	0.31	0.83	1.55	0.48
	E	0.21	0.1	0.09	0.06	0.09	0.08	0.15	0.21	0.13	0.15	0.27	0.54	0.95	1.72	1.52	0.45
	F	0.14	0.06	0.04	0.02	0.04	0.03	0.09	0.2	0.08	0.06	0.15	0.35	0.78	1.34	1.41	0.49
	G	0.04	0.01	0	0	0	0	0.03	0.05	0.03	0.03	0.06	0.15	0.33	0.47	0.64	0.27

Table F.35. (contd)

Average Wind Speed m/s	Atmospheric Stability Class	Percentage of Time Wind Blows from the 200 Area Toward the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
7.15	A	0.05	0.11	0.07	0.02	0.01	0	0.01	0.02	0.02	0.09	0.29	0.37	0.15	0.16	0.48	0.11
	B	0.02	0.02	0.02	0.01	0	0	0	0.01	0.01	0.03	0.05	0.09	0.04	0.06	0.14	0.03
	C	0.01	0.01	0.01	0	0	0	0	0.01	0.01	0.03	0.05	0.07	0.04	0.05	0.12	0.02
	D	0.06	0.08	0.04	0.02	0.01	0.01	0.04	0.08	0.08	0.17	0.34	0.46	0.39	0.85	1.18	0.15
	E	0.07	0.05	0.04	0.02	0.02	0.01	0.05	0.1	0.09	0.14	0.31	0.64	0.9	2.11	1.71	0.15
	F	0.04	0.03	0.03	0.01	0.01	0	0.03	0.08	0.03	0.03	0.06	0.23	0.39	0.88	1.3	0.15
	G	0	0	0	0	0	0	0.02	0.04	0.01	0	0.01	0.05	0.08	0.2	0.61	0.1
9.8	A	0.01	0.03	0.04	0.01	0	0	0	0	0.01	0.03	0.16	0.21	0.06	0.1	0.31	0.03
	B	0	0.01	0	0	0	0	0	0	0	0.01	0.05	0.05	0.01	0.03	0.08	0.01
	C	0	0	0	0	0	0	0	0	0	0.01	0.04	0.04	0.02	0.03	0.05	0.01
	D	0.02	0.03	0.02	0.01	0	0	0	0.02	0.04	0.11	0.29	0.28	0.15	0.51	0.68	0.04
	E	0.02	0.04	0.02	0	0	0	0.01	0.02	0.04	0.09	0.24	0.28	0.2	0.78	1.04	0.03
	F	0	0	0	0	0	0	0	0.01	0.01	0	0.02	0.03	0.04	0.08	0.19	0.01
	G	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.03	0.08	0
12.7	A	0	0	0.01	0	0	0	0	0	0	0.02	0.09	0.1	0.02	0.02	0.16	0.01
	B	0	0.01	0	0	0	0	0	0	0	0.01	0.04	0.03	0.01	0.01	0.05	0
	C	0	0	0	0	0	0	0	0	0	0.01	0.02	0.02	0	0.01	0.04	0
	D	0.01	0.02	0.01	0.01	0	0	0	0.01	0.01	0.1	0.23	0.12	0.04	0.24	0.48	0.01
	E	0	0.02	0.01	0	0	0	0	0	0.02	0.07	0.13	0.08	0.04	0.19	0.39	0
	F	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Average Wind Speed m/s	Atmospheric Stability Class	Percentage of Time Wind Blows from the 200 Area Toward the Direction Indicated															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
15.6	A	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0	0	0.02	0
	B	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0.01	0
	C	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0.01	0
	D	0	0	0	0	0	0	0	0	0	0.04	0.08	0.03	0.01	0.03	0.06	0
	E	0	0	0	0	0	0	0	0	0	0.03	0.04	0.01	0.01	0.03	0.05	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0.01	0.03	0.01	0	0	0	0
	E	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1 **Table F.36**. Population Within 80 km (50 mi) of the 200 Areas

2

Downwind Sector	Distance Interval, mi					
	0-10	**10-20**	**20-30**	**30-40**	**40-50**	**Total**
S	0	959	790	175	4281	6205
SSW	0	180	12,966	293	298	13,737
SW	0	33	30,654	3205	95	33,987
WSW	1	53	2309	23,398	7055	32,816
W	7	37	188	10,558	118,630	129,420
WNW	0	1365	33	10	6178	7586
NW	11	3358	933	92	2336	6730
NNW	4	320	751	1713	7123	9911
N	0	170	2980	438	3018	6606
NNE	0	29	1085	4150	27,277	32,541
NE	0	115	10821	3651	670	15,257
ENE	0	347	1184	1705	220	3456
E	0	548	2387	1953	325	5213
ESE	0	305	1851	514	1301	3971
SE	0	213	51,919	96,942	1250	150,324
SSE	0	2316	17,659	905	7655	28,535
Total	23	10,348	138,510	149,702	187,712	486,295

3

4 **F.1.4   Exposure Scenarios**

5

6   Two exposure scenarios have been used to evaluate the potential impacts to humans from the waste
7 remediation activities: industrial and resident gardener (agricultural). For waterborne pathways, an
8 additional analysis has been performed for the resident gardener scenario to include a sauna/sweat lodge
9 exposure pathway (indicated in the result tables of this appendix as the hypothetical resident gardener
10 with sauna/sweat lodge). These scenarios were chosen to represent a range of habits and conditions for
11 potential exposures. The industrial and resident gardener scenarios are based on the recommendations
12 presented in the Hanford Site Risk Assessment Methodology (HSRAM) (DOE-RL 1995) as adopted by
13 the TPA. These scenarios are based on the concept of reasonable maximum exposure as recommended
14 by EPA (Means 1989) for which the most conservative parameter is not always used. The resident
15 gardener with a sauna/sweat lodge scenario also includes exposure to waterborne contamination used in a
16 sweat lodge (Harris and Harper 1997; DOE-RL 1998) or sauna. The resident gardener with a sauna/sweat
17 lodge scenario is only applied to waterborne pathways because the airborne pathways do not contribute to
18 the sauna/sweat lodge exposure pathways.

1   The present analysis has used the HSRAM scenarios and exposure parameter values as published
2   (DOE-RL 1995). These scenarios and parameters provide a conservative estimate of potential exposures
3   of individuals living on or near the Hanford Site. When the annual radiation dose is evaluated, the
4   HSRAM scenarios are modified to reflect exposure for a one-year period instead of an extended exposure
5   duration. The lifetime impacts can be estimated by multiplication of the annual values by the exposure
6   duration for the scenario (20 years for the industrial scenario and 30 years for the resident gardener
7   scenario).
8
9   Exposure assessments are performed for atmospheric releases (from normal operations) and for long-
10   term transport via groundwater. For normal operations, the exposure assessment uses the results from the
11   atmospheric transport analysis as the starting point for evaluation of pollutant concentrations in exposure
12   media (for example, air, soil, and foods). The analysis begins with the first release from a facility and
13   continues until the releases have stopped and the individuals have been exposed for the prescribed
14   duration for the specific exposure scenario. The operating and waste-handling periods for the facility
15   being considered determine the release period. During the release period, the transported material may be
16   deposited into soil resulting in a gradual increase over time in concentrations of pollutants in soil. The
17   accumulation in soil is evaluated explicitly by the MEPAS program and is used to determine the annual
18   maximum radiation dose and the exposures for each of the exposure scenarios.
19
20   For long-term transport via groundwater, the exposure assessment uses the estimated water
21   concentration at the point of exposure (for example, a point of analysis 1 km from the 200 East Area, a
22   point of analysis 1 km from the 200 West Area, a point of analysis 1 km from the ERDF site, and another
23   point of analysis near the Columbia River). This water is used as the source of domestic water, for
24   irrigation of food crops, animal product feed, and animal drinking water (for the resident gardener
25   scenario).
26
27   Two exposure scenarios are summarized in the following sections. The scenarios are described for
28   exposure pathways involving atmospheric releases, as well as releases resulting in groundwater
29   contamination. The atmospheric pathways are evaluated to estimate health impacts for releases to air
30   from normal operations; waterborne pathways are evaluated to estimate health impacts from releases to
31   soil and transport via groundwater to the environment. A discussion of each exposure pathway follows
32   the scenario descriptions.
33
34   **F.1.4.1 Industrial Scenario**
35
36   The industrial scenario is intended to represent potential exposures to workers in a commercial or
37   industrial setting. The scenario primarily involves indoor activities, but outdoor activities (such as soil
38   contact) are also included. The workers are assumed to wear no protective clothing. The scenario is not
39   intended to represent exposure of remediation workers. For atmospheric releases, the worker is assumed
40   to be located 100 m (328 ft) east of the release point. The specific exposure pathways included in the
41   industrial scenario are listed in Table F.37 for radionuclides, chemicals, and the atmospheric transport
42   medium. Parameter values for the pathways are presented in Table F.38.
43

Table F.37. Industrial Scenario Exposure Pathways

Transport Medium	Exposure Pathway	Chemical	Radionuclide
Air (with deposition to soil)	Ingestion	Yes	Yes
	External	No	Yes
	Dermal absorption	Yes	No
	Soil suspension – inhalation	Yes	Yes
	Air inhalation	Yes	Yes

Table F.38. Industrial Scenario Parameter Values

Exposure Parameters[a]					
Source	Exposure Pathway	Intake Rate	Exposure Frequency, d/yr	Conversion Factors	Other Factors
Air (with deposition to soil)	Soil ingestion	50 mg/d	146	1E-06 kg/mg	--
	Soil external	8 hr/d	146	--	0.8[b]
	Soil dermal absorption	0.2 mg/cm^2/d	146	1E-06 kg/mg	5000 cm^{2}[c]
	Soil suspension –inhalation	20 m^3/d	250	1E-09 kg/µg	50 µg/m^3 [d]
	Air inhalation	20 m^3/d	250	--	--

(a) For all cases, the body weight is 70 kg (155 lb). The exposure period is 1 year for annual dose estimates
      and 20 years for other analyses.
(b) Average shielding factor for external exposure to contaminated soil.
(c) Skin surface area contacted with soil by the worker.
(d) Average particulate loading in air.

F.1.4.2 Resident Gardener Scenario

The resident gardener scenario is intended to represent potential exposures to an individual living
near the Hanford Site and raising food and animal products for home consumption. The agriculture
scenario from the HSRAM is applied to atmospheric and groundwater transport pathways. This scenario
is the same as the agricultural scenario representing the point of maximum offsite air concentration for
routine releases. The specific exposure pathways for radionuclides and chemicals that are included in the
resident gardener scenario are listed in Table F.39. Parameter values for each exposure pathway are
presented in Table F.40.

Several different exposure pathways are considered in the health impacts analyses. The pathways
included in a specific analysis depend on the transport medium, scenario, and pollutant type (that is,
chemical or radionuclide), as indicated in the previous section. Details of each exposure pathway are
presented here by transport medium. In general, the parameter values for a pathway are taken from the
HSRAM report (DOE-RL 1995) and from Harris and Harper (1997) and DOE-RL (1998) for the
sauna/sweat lodge pathway.

Table F.39. Resident Gardener Scenario Exposure Pathways

Transport Medium	Exposure Pathway	Chemical	Radionuclide
Soil (air deposition)	Ingestion	Yes	Yes
	External	No	Yes
	Dermal absorption	Yes	No
	Biota – dairy	Yes	Yes
	Biota – meat	Yes	Yes
	Biota – game (deer)	Yes	Yes
	Biota – fruit	Yes	Yes
	Biota – vegetables	Yes	Yes
	Suspension – inhalation	Yes	Yes
Air	Inhalation	Yes	Yes
	Biota – dairy	Yes	Yes
	Biota – meat	Yes	Yes
	Biota – game (deer)	Yes	Yes
	Biota – fruit	Yes	Yes
	Biota – vegetables	Yes	Yes
Groundwater	Ingestion	Yes	Yes
	Dermal absorption (bathing)	Yes	No
	Biota – dairy	Yes	Yes
	Biota – meat	Yes	Yes
	Biota – game (deer)	Yes	Yes
	Biota – fruit	Yes	Yes
	Biota – vegetables	Yes	Yes
	Inhalation indoor	Yes	Yes

1

Table F.40. Resident Gardener Scenario Exposure Factors

2

Exposure Parameters [a]					
Source	**Exposure Pathway**	**Intake Rate**	**Exposure Frequency, d/yr**	**Conversion Factors**	**Other Factors**
Soil	Ingestion	100 mg/d	365	1E-06 kg/mg	--
	External	24 hr/d	365	--	0.8[b]
	Dermal absorption	0.2 mg/cm^2/d	180	1E-06 kg/mg	5000 cm$^{2[c]}$
	Inhalation	20 m^3/d	365	1E-09 kg/μg	50 μg/m$^{3[d]}$
Air	Inhalation	20 m^3/d	365	--	--
Groundwater	Ingestion	2 L/d	365	--	--
	Inhalation (sauna or sweat lodge)	20 m^3/d	365	--	1.9 L/m$^{3[e]}$ VOC 0.3 L/m$^{3[g]}$ non-volatile 1 hr/d$^{[f]}$ 4 L/d
	Dermal absorption	0.17 hr/d	365	1E-03 L/cm^3	20,000 cm$^{2[g]}$
Biota	Dairy	300 g/d	365	1E-03 kg/g	--
	Meat	75 g/d	365	1E-03 kg/g	--
	Game	15 g/d	365	1E-03 kg/g	--
	Fruit	42 g/d	365	1E-03 kg/g	--
	Vegetable	80 g/d	365	1E-03 kg/g	--

(a) For all cases the body weight is 70 kg (155 lb). The exposure period is for 1-year annual dose estimates and 30 years for other analyses.
(b) Average shielding factor for external exposure to contaminated soil.
(c) Skin surface area contacted with soil by the worker.
(d) Average particulate loading in air.
(e) The sauna or sweat lodge transfer factor (1.9 L/m^3) for VOCs assumes 4 L/d water use in a hemisphere of a 2-m (6.6-ft) diameter with complete suspension of all contaminants.
(f) Ratio of indoor air concentration to water concentration for volatilization from indoor water uses.
(g) Skin surface area contacted during bathing with domestic water.

3

F.1.4.3 Soil (Air or Irrigation Water Deposition) Transport Medium

Deposition of airborne activity on soil would result in exposure to individuals who come in contact with the soil, breathe resuspended particles from the soil, or eat foods grown in the soil. The contamination deposited onto soil is modeled as a pollutant concentration per unit area of soil. Some of the soil exposure pathways require concentration to be expressed in units of soil mass (mg/kg or pCi/kg dry soil). For these pathways, the conversion to soil mass is made using the conversion factor 60 kg/m^2 that is based on uniform distribution of the contaminant in the top 4 cm (1.6 in.) of soil having a density of 1.5 g/cm^3. This thickness is representative of the distribution of contaminants in residential soil (such as lawns) for deposition occurring over extended periods (for instance, several years). For agricultural pathways, the conversion is based on uniform distribution in 15 cm (6 in.) of soil (plow layer) with a conversion factor of 225 kg/m^2.

The parameter values for each exposure pathway related to soil as a medium have been presented in the preceding tables for the three exposure scenarios. Notes on the exposure pathways follow.

Soil Ingestion. The individual is assumed to inadvertently ingest contaminated soil as part of daily activities defined for the scenarios. The resident gardener ingests soil at 100 mg/day for the entire year, while the industrial worker ingests 50 mg/day while on the job for 146 days per year. It is assumed the worker is exposed to soil for only 146 of the 250 workdays per year.

Soil External Exposure. Radionuclides deposited onto soil may cause external radiation exposure to individuals near the contamination. The industrial worker is assumed to be exposed 8 hours per day for 146 days per year. The resident gardener is exposed 24 hours per day for 365 days per year.

Soil Dermal Contact. The dermal contact pathway is evaluated only for chemicals (as recommended in DOE-RL 1995). The individuals are assumed to have one contact event per day (a 12-hour period) with soil adhering to the skin at a surface density of 0.2 mg/cm^2 of skin for the industrial and resident gardener scenarios. The area of skin contacted is assumed to be 5000 cm^2 for all scenarios. The industrial worker is exposed 146 days per year; the resident gardener is exposed 180 days per year.

Soil Resuspension Inhalation. Material deposited on the ground is assumed to be available for resuspension and inhalation by individuals in proximity to the contamination. The industrial worker and resident gardener scenarios assume the individual inhales 20 m^3 (706 ft^3) of contaminated air per day. The airborne concentration of soil is evaluated using the mass loading factor approach with a particulate air concentration to 50 μg/m^3 of soil in air.

Food Crops. Food crops are evaluated as fruits and vegetables for the resident gardener scenario. The crops are contaminated when soil contamination (from airborne deposition or irrigation water application) transfers to the edible parts of the plant by root uptake. The resident gardener is assumed to eat food crops at a rate of 42 g/day (1.48 oz/d) of fruit and 80 g/day (2.82 oz/d) of vegetables throughout each year of the 30-year exposure period. The soil concentration is based on a soil mixing depth of 15 cm (5.9 in.) and a soil density of 1.5 g/cm^3, which is equivalent to an areal soil density of 225 kg/m^2.

1   **Game (Deer)**. For the resident gardener scenario, the individual is assumed to hunt and kill one deer
2   in the year. The deer becomes contaminated when foraging on plants grown in contaminated soil. The
3   HSRAM scenario applies a hunter success rate of 19 percent for a season. This percentage is appropriate
4   when the exposure duration is many years (30 years for HSRAM), but is not appropriate when
5   considering a one-year period. The annual dose analysis must assume the hunter is successful (a success
6   rate equal to 100 percent for the year of exposure). Also, the HSRAM intake rate for deer meat is based
7   on the amount of animal fat in the consumed meat. Although this assumption may be appropriate for
8   organic chemical pollutants that are lipophilic, it is not generally appropriate for radionuclides. Also, the
9   exposure pathway models for radionuclides evaluate the activity in the edible meat, not fat. The intake
10   rate for deer meat, therefore, must be adjusted to represent the amount of meat ingested. This value is
11   15 g/day (0.53 oz/d), as calculated and reported for the recreational scenario of the Columbia River
12   Comprehensive Impact Assessment (CRCIA) project (DOE-RL 1998).
13
14   **Meat and Milk Ingestion**. Individuals in the resident gardener scenario are assumed to ingest
15   75 g/day (2.65 oz/d) of meat (other than game), and 300 g/day (10.6 oz/d) of dairy products (represented
16   as milk). The animal product becomes contaminated when the animal eats feed crops contaminated by
17   root uptake from contaminated soil.
18
19   ### F.1.4.4 Air Transport Medium
20
21   Airborne activity may result in inhalation exposure plus direct transfer to plant surfaces, resulting in
22   intake of contaminated food crops and animal products (from animals that eat contaminated feed crops).
23   The parameter values for each exposure pathway related to air as a medium have been presented in
24   Tables F.36 and F.38 for the two exposure scenarios. Notes on the exposure pathways follow.
25
26   **Inhalation**. For the two HSRAM scenarios, the individual inhales 20 m^3 (706 ft^3) of air during the
27   time the individual is present. For the industrial worker, this volume of air is inhaled during an 8-hour
28   period, during which the individuals are engaged in enhanced physical activity. For the resident gardener,
29   the air is inhaled during a 24-hour period at average daily inhalation rates. The industrial worker is
30   exposed 250 days per year; the resident gardener is exposed 365 days per year.
31
32   **Food Crops**. Food crops are evaluated as fruits and vegetables for the resident gardener scenario.
33   The crops are contaminated when airborne contamination transfers directly to the plant surface and is
34   incorporated into edible parts of the plant. Parameters for this pathway are defined in Section F.1.4.3.
35
36   **Game (Deer)**. For the resident gardener scenario, the individual is assumed to hunt and kill one deer
37   in the year. The dose for this pathway is evaluated as described under Section F.1.4.3. Deer are
38   potentially contaminated for the air transport medium when they eat plants contaminated from direct air
39   deposition onto plant surfaces plus root uptake of airborne deposition onto soil.
40
41   **Meat and Milk Ingestion**. The animals are exposed from eating feed crops that may be
42   contaminated by direct air deposition plus root uptake of airborne deposition onto soil. Parameters for
43   these pathways are defined in Section F.1.4.3.
44

F.1.4.5 Waterborne Transport Medium

Waterborne activity may result in exposure from domestic water uses and irrigation water uses. Groundwater used to supply drinking water for domestic water for residences can result in exposure via water ingestion, inhalation of volatile chemicals released during showering and washing, and dermal contact during bathing. The parameter values for each exposure pathway related to groundwater as a medium have been presented in Tables F.36 and F.38. Notes on the exposure pathways follow.

Ingestion of Drinking Water. The resident gardener consumes 2 L/day (0.53 gal/d) during each day of the year.

Indoor Air Inhalation. Individuals may be exposed to contaminated indoor air from volatilization of chemicals from indoor uses of domestic water. This exposure includes air inhalation while showering. The resident gardener is exposed daily with a breathing rate of 20 m^3 (706 ft^3) per day.

Sauna or Sweat Lodge Air Inhalation. Individuals who participate in sauna or sweat lodge activity may be exposed to contaminated air from the contaminants in water used to generate humidity. The amount of a pollutant transferred to air from the water is dependent on the physical properties (volatility) of the pollutant and the amount of water used. The typical use of water is 4 L (1.01 gal) over a 1-hour period. Volatile chemicals could be totally transferred to the air. Using a sauna or sweat lodge volume based on a 2-m (6.6-ft) diameter hemisphere (Harris and Harper 1997), the transfer factor is 1.9 L/m^3 (4 L [1.01 gal]) water per volume of 2-m (6.6-ft) diameter hemisphere. This value relates the air concentration inside the sauna or sweat lodge to the water concentration used to generate the humidity.

The transfer of non-volatile compounds (and most radionuclides) is determined by the amount of water vapor that can be held in the air. Excess water vapor (and associated non-volatile pollutants) would condense and be removed from the air. The estimated transfer factor of 0.3 L/m3 is based on recommendations of Harris and Harper (1997) and is intended to maximize the concentration of non-volatile compounds in the air.

Water Dermal Contact. Individuals may be exposed to contaminated water while bathing. Dermal absorption of chemicals in shower water is evaluated using methods recommended by the EPA (EPA 1992). Residents are exposed each day of the year.

Food Crops, Game (Deer), Meat, and Milk Ingestion. Parameter values for these exposure pathways are as defined in Section F.1.4.3.

F.1.5 Soil Accumulation Model

The accumulation of pollutants in soil is represented using a box model with loss rate constants to represent radioactive decay, leaching, and volatilization of volatile and semi-volatile compounds.

The losses from volatilization are represented by a loss rate constant that was evaluated based on physical properties of the chemical. The loss rate constants were evaluated using the volatilization model

1 of Streile et al. (1996) with soil parameters defined for Hanford agricultural soil (Sandy Loam). The
2 evaluation was performed using the MEPAS 4.0 source term component under the FRAMES operating
3 system (Whelan et al. 1997). The estimated half times are presented in Table F.41.
4
5 **Table F.41**. Volatilization Half Times for Soil
6

Chemical	Soil Half Time Volatilization (Days)
Acetone	4.00E+02
Bromodichloromethane	3.80E+02
Carbon tetrachloride	1.20E+02
Dichloromethane	5.10E+01
Diesel fuel	8.50E+03
Hydraulic fluid	8.70E+03
Methyl ethyl ketone	8.40E+02
Polychlorinated biphenyls (PCBs)	4.40E+04
p-chloroaniline	1.40E+04
Toluene	2.70E+02
1,1,1 Trichloroethane	2.30E+02
Xylene	2.20E+02
(a) PCBs = polychlorinated biphenyls.	

7
8   The losses from radioactive decay (and progeny generation) are evaluated using the general decay
9 algorithm of Strenge (1997).
10
11   The leaching losses from the surface soil layer are evaluated from the distribution coefficient (K_d)
12 value as shown in Equation F.2.
13

14
$$\lambda_i = \frac{I}{h\,\theta\,(1 + \frac{\beta_d}{\theta}\,k_{di})}$$
(F.2)

15 where λ_i = loss rate constant for pollutant i from surface soils (1/yr)
16   I = total infiltration rate (cm/yr)
17   h = thickness of the surface-soil layer (cm)
18   θ = moisture content of the surface-soil layer (fraction)
19   β_d = bulk density of the surface-soil layer (g/cm^3).
20   k_{di} = distribution coefficient for pollutant i (mL/g)

1   Evaluation of the leach rate constant requires an estimate of the K_d for each contaminant. The
2 following paragraphs describe the method used to evaluate the K_d values for radionuclides and chemicals.
3
4   Values used for the distribution coefficient were selected to give low leach rate constants (high
5 retention times). This selection would result in a conservative (high) estimate of radiation dose or
6 chemical intake for those exposure pathways that involve accumulation in soil. The parameters for
7 agricultural soil are used for all exposure pathways, as a simplification to the analysis and a further
8 conservatism for the residential exposure pathways. Residential soil would be expected to involve mixing
9 in a smaller depth (represented in Equation F.2 by parameter h). A smaller value for soil depth would
10 result in a faster leach rate and lower equilibrium concentrations. Residential and industrial soils are
11 assumed subject to the same infiltration rate as agricultural lands because of lawn watering.
12

13 ### F.1.5.1 Evaluation of Distribution Coefficient for Organic Chemicals
14

15   The general algorithm for estimation of K_d values for organic chemicals is taken from Strenge and
16 Peterson (1989) as shown in Equations F.3 and F.4:
17

18
$$K_d = 0.0001 \, K_{oc} \, S_d \tag{F.3}$$

19
20 where K_d = distribution coefficient (mL/g)
21   K_{oc} = carbon matter water distribution coefficient (mL/g)
22   S_d = soil distribution coefficient (dimensionless)
23   0.0001 = empirical coefficient.
24

25   The soil distribution coefficient is evaluated based on soil properties as follows:
26

27
$$S_d = 57.735 \, (\% \; organic \; matter) + 2.0 \, (\% \; clay) + 0.4 \, (\% \; silt) + 0.005 \, (\% \; sand) \tag{F.4}$$

28
29 where the empirical coefficients have units of 1 percent.
30
31 As this equation indicates, the soil composition is important to the evaluation of the K_d. For the present
32 analysis, the soil type is based on an agricultural soil composed of typical Hanford soil, with the carbon
33 matter composition based on typical agricultural soils. Surface soils of Hanford are dominated by
34 Ruppert Sand, Ephrata Sandy Loam, and Burbank Loamy Sand (see Section 4.3.4). The approximate
35 composition of these soils is indicated in Table F.42.
36

1   **Table F.42**. Soil Classification Composition

2

Soil Classification	% Sand	% Silt	% Clay
Sand	92	5	3
Loamy Sand	83	11	6
Sandy Loam	65	25	10

3

4   The properties of Sandy Loam provide higher estimates of K_d than the other two soil types because

5 clay results in a higher contribution to the soil distribution coefficient than the other two components.

6 Typical agricultural soils contain about 1.2 percent organic carbon (Connor and Shacklette 1975).

7 Assuming the weight of organic carbon is about half of the weight of the organic matter, the total content

8 of organic matter is about 2.4 percent.

9

10   The estimate of S_d and K_d is based on Sandy Loam with a carbon matter content of 2.4 percent, with

11 the carbon matter percent value replacing sand. The net composition is 62.6 percent sand, 25 percent silt,

12 10 percent clay, and 2.4 percent carbon matter. This soil composition results in a value of 169 for S_d.

13

14   The K_{oc} values are taken from the MEPAS chemical database. Evaluation of K_d values is indicated in

15 Table F.43 for the hazardous organic chemicals in the waste stream inventories.

16

17   **Table F.43**. Soil-Related Properties of Hazardous Organic Chemicals

18

Chemical	K_{oc}	K_d
Beryllium	--[a]	1.0E+02
Nitric acid	--	1.0E+01
Sodium nitrate	--	1.0E+01
Sodium hydroxide	--	1.0E+01
1,1,1 trichloroethane	1.52E+02	2.57E+0
Polychlorinated biphenyls	6.10E+05	1.03E+04
p-chloroaniline	4.17E+01	7.04E-01
Carbon tetrachloride	5.02E+02	8.48E+0
Hydraulic fluid	1.40E+04	2.36E+02
Toluene	3.00E+02	5.07E+0
Formic acid	1.8E-01	3.04E-03
Dichloromethane	8.8E+0	1.49E-01
Acetone	5.75E-01	9.7E-02
Methyl ethyl ketone (MEK)	4.5E+0	7.6E-02
Diesel fuels	4.50E+03	7.6E+01
Xylene	2.40E+02	4.05E+0
Mercury	--	8.00E+04
Bromodichloromethane	1.07E+02	1.81E+0
(a) A K_{oc} value is not needed for inorganic chemicals.		

1 ### F.1.5.2 Evaluation of Distribution Coefficients for Radionuclides and Inorganic
2 ### Chemicals
3
4   The distribution coefficient values for radionuclides and inorganic chemicals were selected based on a
5 literature review values for the inorganic chemicals and radionuclide elements in the waste stream
6 inventories. The selected K_d values are listed in Table F.44.
7
8   The K_d value for sodium nitrate, sodium hydroxide, and nitric acid are based on the value used for
9 potassium-40, and the value for mercury is the same as the value for lead. The values are based primarily
10 on chemical similarity and solubility. The value for beryllium is a default value set to cause very little
11 leaching (a conservative estimate for impacts).
12
13   **Table F.44**. Distribution Coefficients of Radionuclides and Inorganic Chemicals
14

Analyte Name[a]	Distribution Coefficient (mg/g)
Americium	5000
Beryllium	100
Bismuth	900
Cesium	100
Cobalt	100
Curium	1500
Iron	100
Lead	80,000
Manganese	2400
Mercury	80,000
Neptunium	1500
Nickel	2400
Nitrate	10
Nitrite	10
Plutonium	5000
Polonium	1100
Protactinium	3600
Radium	500
Radon	0.1
Sodium hydroxide	10
Strontium	180
Thorium	600,000
Tritium	0.7
Uranium	7
Yttrium	1500
(a) The distribution coefficient applies to all isotopes of the listed element.	

15

F.1.6　Health Impacts

The evaluation of annual radiation dose is based on radiation dose conversion factors as published in Federal Guidance Reports Nos. 11 and 12 (Eckerman et al. 1988; Eckerman and Ryman 1993). These dose factors are based on recommendations of the International Commission on Radiological Protection (ICRP) as given in ICRP Publication 30 (ICRP 1979, 1980, 1981, 1988). The resulting doses represent the effective dose equivalent received over a commitment period of 50 years following intake in the first year.

For non-carcinogenic chemicals, the health endpoint is the hazard quotient defined by EPA as the average daily intake of a chemical divided by the reference dose (RfD) for that chemical. The hazard quotient is evaluated for both inhalation exposures and ingestion exposures with RfD determined for each route. For carcinogenic chemicals, the health endpoint is the lifetime cancer incidence from the defined total intake.

The evaluation of radiation dose as the endpoint in the analysis is a deviation from the guidance in the HSRAM report (DOE-RL 1995). The HSRAM report describes evaluation of the lifetime cancer incidence risk from radionuclides using slope factors. The slope factors relate intake (pCi) to the lifetime cancer incidence risk. However, the present analysis requires evaluation of annual radiation dose. The use of slope factors has, therefore, been replaced in the present analysis by use of radiation dose conversion factors.

F.1.7　Basis for Radiological Health Consequences

Estimates of consequences from radiological exposures to workers and the public are based on recommendations of the EPA, as presented in Federal Guidance Report 13 (Eckerman et al. 1999). The consequences in terms of LCFs and total detrimental health effects are presented in Table F.45 for both adult workers and the general population. The total incidence of detrimental health effects includes both fatal and non-fatal cancers and severe hereditary effects.

The EPA recommendations are similar to those of the ICRP (1991), which are shown in Table F.46. Again, the total incidence of detrimental health effects includes both fatal and non-fatal cancers and severe hereditary effects. The higher rates for health effects in the general population account for the presence of more sensitive individuals, such as children, compared to the relatively homogeneous population of healthy adults in the workforce. These health effects coefficients are used to estimate the number of LCFs in populations, or the risk of an LCF to an individual, for the purposes of comparing the alternatives and activities discussed in this HSW EIS. The ICRP health effects coefficients have been adopted by the National Council on Radiation Protection and Measurements (NCRP 1993) and are similar to those developed by other organizations (for example, UNSCEAR 1988; Eckerman et al. 1999). Use of the health effects coefficients developed by these other organizations would result in conclusions regarding health effects similar to those presented in this HSW EIS.

1 **Table F.45**. Summary of Basis for Health Consequences from Radiological Exposures from
2 Federal Guidance Report No. 13 (Eckerman et al. 1999)
3

Type of Health Effect	Effects per Unit Radiation Dose[a]	Radiation Dose to Produce 1 Effect[a]
Latent Cancer Fatality All Individuals	6×10^{-4} /person-rem	1700 person-rem
Total Detriment[b] All individuals	8.5×10^{-4} /person-rem	1200 person-rem
(a) To convert person-rem to person-Sv, multiply by 0.01. (b) Total Detriment includes fatal and non-fatal cancers and severe hereditary effects.		

4

5 The health effects coefficients are based on radiation exposures to specific populations and for
6 different doses, dose rates, and pathways than those normally encountered in the environment. As a
7 result, the health effects coefficients in Table F.46 are subject to substantial uncertainty when applied to
8 very low or very high doses, and when extrapolated to estimate health effects in populations different
9 from those used to develop them. The NCRP (1997) has estimated the range (90 percent confidence
10 interval) of these health effects coefficients to be approximately a factor of two above and below the
11 median values presented in Table F.46.

12

13 The estimation of health effects in a given population is determined by applying the health effects
14 coefficients to the collective dose for that population. Collective dose is defined as the sum of doses to all
15 individuals in the population who may exhibit a wide range of susceptibility to radiation-induced health
16 effects. The health effects coefficients are, therefore, associated with substantial uncertainty when
17 applied to dose estimates for individuals whose sensitivity may differ from the population average.
18 However, assumptions used to develop the health effects coefficients were intended to be sufficiently
19 conservative, in that they would be "…unlikely to underestimate the risks" (ICRP 1991).

20

21 **Table F.46**. Basis for Health Consequences from Radiological Exposures (from ICRP 1991)

22

Type of Health Effect	Effects per Unit Radiation Dose[a]	Radiation Dose to Produce 1 Effect[a]
Latent Cancer Fatality		
Adult Workers	4×10^{-4} /person-rem	2500 person-rem
General Population	5×10^{-4} /person-rem	2000 person-rem
Total Detriment[b]		
Adult Workers	5.6×10^{-4} /person-rem	1800 person-rem
General Population	7.3×10^{-4} /person-rem	1400 person-rem
(a) To convert person-rem to person-Sv, multiply by 0.01. (b) Total Detriment includes fatal and non-fatal cancers and severe hereditary effects		

23

24 For radiological accidents discussed in this HSW EIS, the doses estimated for some hypothetical
25 events may be greater than the doses to which the ICRP health effects coefficients were intended to apply.

1 Depending upon the radionuclides involved and the exposure pathways considered, the LCF risk may be
2 as much as twice that listed in Table F.45 for doses greater than 20 rem but less than a few hundred rem.
3 For doses greater than a few hundred rem, there is a potential for short-term health effects other than
4 cancer and hereditary effects (again, depending upon the radionuclides and exposure pathways associated
5 with a particular accident scenario). For a further discussion of uncertainties see Section 3.5 in Volume I
6 of this EIS.
7
F.1.8   Comparison of Radiation Risk Results for Children Estimated Using
8
9   Federal Guidance Reports 11 and 13
10
11   All dose results in this EIS have been estimated using the internal radiation dose conversion factors
12 recommended in Federal Guidance Report (FGR) 11 (Eckerman et al. 1988). As an approximation,
13 radiation risks were estimated using an individual dose-to-risk conversion factor of 0.0006 risk of
14 induction of a latent cancer fatality per rem of dose, as recommended by the Interagency Steering
15 Committee on Radiation Standards (ISCORS). All estimates presented in this EIS are based on exposure
16 of adults.
17
18   Radiation doses and risks to children are different than those to adults for the same concentrations of
19 contaminants in the environment, because children generally eat and drink less than adults (except
20 possibly for milk) so their bodies metabolize contaminants differently than adults, and their organs have
21 different masses than adult organs. In addition, children may have different sensitivities than adults to
22 radiation for a given radiation dose. FGR 13 (Eckerman et al. 1999) provides tables of ingestion dose and
23 risk to children for a unit intake of radionuclides that may be used to evaluate the potential differences in
24 dose and risk to children and adults for given groundwater concentrations of radionuclides of interest in
25 this EIS.
26
27   The radiation risks for adults in this EIS are estimated using predicted radionuclide concentrations in
28 waster, assumed drinking rates, radionuclide-specific radiation dose conversion factors, and a dose-to-risk
29 conversion. A similar calculation can be done using a drinking rate appropriate for children, and the
30 radionuclide-specific risk conversion factor. The ratios of annual dose and risks estimated for children,
31 using a 1 L/day drinking water intake rate, to the annual risk for adults, as calculated in this EIS, are
32 presented in Table F.47.
33
34   The EIS approach would over-estimate the risk to children from ingestion of iodine-129, but slightly
35 underestimate the dose. Doses and risks to children from carbon-14 would be about twice as high as for
36 adult; however, carbon-14 was found to be a minor contributor to dose for all alternatives. Risks to
37 children from technetium-99 would be an order of magnitude greater and doses would be a factor of 6
38 greater. Technetium-99 was found to be a major contributor to drinking water dose for several millennia
39 and although the risk to children would be higher, the annual dose was found to not exceed 4 mrem using
40 the higher factor. The methods used for adults are approximately the same for children for isotopes of
41 uranium.
42

Table F.47. Ratios of Dose and Risk to Children over Dose and Risk to Adults
from 1-Year Ingestion of Contaminated Drinking Water

Radionuclide	Dose Ratio (Child/Adult)	Risk Ratio (Child/Adult)
C-14	1.4	2.3
Tc-99	6.0	11
I-129	1.4	0.2
U-233	0.88	1.1
U-234	0.87	1.1
U-235	0.90	1.2
U-236	0.87	1.1
U-238	0.88	1.1

F.2 Accident Impact Assessment Methods

In this HSW EIS, estimates of accident consequences for Hanford waste management facilities and operations are based on analyses of accident scenarios identified in existing Hanford nuclear facility safety analyses, including Bushore (2001), Tomaszewski (2001), Vail (2001a, 2001b, 2001c), and WHC (1991). Details of the accident analyses are presented in these documents and are summarized in Section 5.11.

The accident consequences presented in this HSW EIS differ from those in the Hanford safety documents because of differences and calculation adjustments that are described in the following paragraphs. Adjustments were made to the analysis results to update calculations and to meet the needs of the environmental impact analysis rather than those of the safety analyses for which the analyses were originally prepared. Except for those changes and adjustments specifically noted, all calculations and assumptions remain the same.

Changes and adjustments to safety document calculations include the following:

1. Updated Hanford meteorological data were used to estimate atmospheric dispersion factors. Composite joint frequency data, including the years 1983 through 1996, were used for this HSW EIS analysis.

2. The environmental impact analysis used 95th percentile atmospheric dispersion factors, whereas safety analyses typically used 99.5 percentile atmospheric dispersion factors. (Building wake and plume meander factors used in the safety analyses remain incorporated in this HSW EIS consequence estimates.)

3. The locations of the MEI member of the public and the MEI non-involved worker were changed from those in the safety analyses. For this HSW EIS analysis, the MEI was located at the nearest publicly accessible location on U.S. State Route 240 (generally 3 to 5 km [1.9 to 3.1 mi] distant), and the